11-14-00 A

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Approved for use through 09/30/00. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	124-00100	Total Pages	22
First Named Inventor or Application Identifier			
HENRIK JAKOBSEN			
Express Mail Label No.	EL661112713US		

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents

ADDRESS TO: Assistant Commissioner for Patents
Box Patent Application
Washington, D.C. 20231

1. ☒ Fee Transmittal Form
(Submit an original, and a duplicate for fee processing)

2. ☒ Specification [Total Pages 10]
(preferred arrangement set forth below)
- Descriptive title of the Invention
- Cross References to Related Applications
- Statement Regarding Fed sponsored R & D
- Reference to Microfiche Appendix
- Background of the Invention
- Brief Summary of the Invention
- Brief Description of the Drawings (if filed)
- Detailed Description
- Claim(s)
- Abstract of the Disclosure

3. ☒ Drawing(s) (35 USC 113) [Total Sheets 2]

4. Oath or Declaration [Total Pages 3]
a. ☒ Newly executed (original or copy)
b. ☐ Copy from a prior application (37 CFR 1.63(d))
(for continuation/divisional with Box 17 completed)
[Note Box 5 below]
i. ☐ DELETION OF INVENTOR(S)
Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).

5. ☐ Incorporation By Reference (useable if Box 4b is checked). The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

6. ☐ Microfiche Computer Program (Appendix)

7. Nucleotide and/or Amino Acid Sequence Submission
(if applicable, all necessary)
a. ☐ Computer Readable Copy
b. ☐ Paper Copy (identical to computer copy)
c. ☐ Statement verifying identify of above copies

ACCOMPANYING APPLICATION PARTS

8. ☐ Assignment Papers (cover sheet & document(s))

9. ☐ 37 CFR 3.73(b) Statement ☐ Power of Attorney
(when there is an assignee)

10. ☐ English Translation Document (if applicable)

11. ☐ Information Disclosure Statement (IDS)/PTO-1449 ☐ Copies of IDS Citations

12. ☒ Preliminary Amendment

13. ☒ Return Receipt Postcard (MPEP 503)
(Should be specifically itemized)

14. ☐ Small Entity Statement(s) ☐ Statement filed in prior application, Status still proper and desired

15. ☐ Certified Copy of Priority Document(s)
(if foreign priority is claimed)

16. ☒ Other: Certificate of Express Mail

17. If a CONTINUING APPLICATION, check appropriate box and supply the requisite information:
☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No.: ____/____.

18. CORRESPONDENCE ADDRESS

☐ Customer Number or Bar Code Label [Insert Customer No. or Attach bar code label here] or ☒ Correspondence address below.

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Dawn M. Oleszak	November 13, 2000
Name	Date
Dawn M. Oleszak	11-13-00
Signature	Date

Approved for use through 9/30/98
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

PTO/SB/17
(10/97)

FEE TRANSMITTAL

COMPLETE IF KNOWN	
Application Number	
Filing Date	
First Named Inventor	Henrik Jakobsen
Group Art Unit	
Examiner Name	
Attorney Docket Number	124-00100

Total Amount of Payment ($) 728.00

METHOD OF PAYMENT (check one)

1. ☐ The Commissioner is hereby authorized to charge indicated fees and credit any over payments to:

Deposit Account Number: 01.2000

Deposit Account Name: ANDRUS, SCEALES, STARKE & SAWALL

☒ Charge any additional fee required under 37 CFR 1.16 and 1.17

☐ Charge the Issue Fee set in 37 CFR 1.18 at the Mailing Of the Notice of Allowance, 37 CFR 1.311(b)

3. ☒ Payment Enclosed:
☒ Check ☐ Money Order ☐ Other

FEE CALCULATION (fees effective 12/29/99)

1. **Filing Fee**

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)		
101	710	201	355	Utility filing fee	710
106	320	206	160	Design filing fee	
107	490	207	245	Plant filing fee	
108	710	208	355	Reissue filing fee	
114	150	214	75	Provisional filing fee	

SUBTOTAL (1) ($) 710.00

2. **Claims**

	Extra		Fee from below		Fee Paid
Total claims 21 -20=	1	X	18	=	18
Independent 2 - 3=	0	X	80	=	0
Multiple Dependent Claims		X		=	

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
103	18	203	9	Claims in excess of 20
102	80	202	40	Independent claims in excess of 3
104	270	204	135	Multiple dependent claim
109	80	209	40	Reissue independent claims over original patent
110	18	210	9	Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($) 18.00

FEE CALCULATION (continued)

2. **Additional Fees**

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge-late filing fee or oath	
127	50	227	25	Surcharge-late provisional filing fee or cover sheet	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for response within first month	
116	390	216	195	Extension for response within second month	
117	890	217	445	Extension for response within third month	
118	1,390	218	695	Extension for response within fourth month	
128	1,890	228	945	Extension for response within fifth month	
119	310	219	155	Notice of appeal	
120	310	220	155	Filing a brief in support of an appeal	
121	270	221	135	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive unavoidably abandoned application	
141	1,240	241	620	Petition to revive unintentionally abandoned application	
142	1,240	242	620	Utility issue fee (or reissue)	
143	440	243	300	Design issue fee	
144	600	244	300	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Petitions related to provisional applications	
126	240	126	240	Submission of Information Disclosure Statement	
581	40	581	40	Recording each patent assignment per property (times number of properties	
146	710	246	355	Filing a submission after final rejection (37 CFR 1.129(a))	
149	710	249	355	For each additional invention to be examined (37 CFR 1.129(b))	
Other fee (specify)					
Other fee (specify)					

SUBTOTAL (3) ($) 0

*Reduced by Basic Filing Fee Paid

SUBMITTED BY

		COMPLETE (if applicable)			
Type or Printed name	Andrew S. McConnell Andrus, Sceales, Starke & Sawall, LLP	Registration Number		32,272	
Signature	Andrew S. McConnell	Date	11/13/00	Deposit Account User ID	

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application Of:	)
	)
HENRIK JAKOBSEN ET AL	)
	)
Filed Herewith	)
	)
IMPROVEMENTS TO MICRO-ELECTROMECHANICAL DEVICES	)

PRELIMINARY AMENDMENT

COMMISSIONER FOR PATENTS
Washington, D.C. 20231

Sir:

Please enter the following preliminary amendment prior to examination of the above application.

IN THE CLAIMS

4. (Amended) A device according to [any one of the preceding claims] claim 1, wherein the second softer or more malleable layer is formed from one of aluminium or gold.

5. (Amended) A device according to [any one of the preceding claims] claim 1, wherein the first layer or set of layers is approximately 7000 Å thick.

6. (Amended) A device according to [any one of the preceding claims] claim 1, wherein the first layer or set of layers is approximately 3000 Å thick to 10000 Å thick.

7. (Amended) A device according to [any one of the preceding claims] claim 1, wherein the second layer is approximately 5000 Å thick.

8. (Amended) A device according to [any one of the preceding claims] claim 1, wherein the second layer is approximately 2000 Å to 6000 Å thick.

9. (Amended) A device according to [any one of the preceding claims] claim 1, wherein additional titanium is formed on one or more of the surfaces that form the inner surface of a sealed cavity in the completed device.

13. (Amended) A method according to [any one of claims] claim 10 [to 12], wherein the hard layer is the first layer to be deposited on the glass and, subsequently, the second layer is deposited on top of the first layer.

14. (Amended) A method according to [any one of claims] claim 10 [to 13], wherein the layers are then subjected to two or more photolithography steps which firstly pattern the press contacts and wire bond pads in to the second layer and, secondly, pattern the conductors and electrodes in to the first layer.

15. (Amended) A method according to [any one of claims] claim 10 [to 14], wherein additional titanium is formed on one or more of the surfaces that form the inner surface of a sealed cavity in the completed device.

16. (Amended) A method according to [any one of claims] claim 10 [to 15], wherein the titanium acts as a getter to reduce the gas pressure in a sealed cavity after anodic bonding.

17. (Amended) A method according to [any one of claims] claim 10 [to 16], wherein the titanium acts as a getter to reduce the gas pressure in a sealed cavity after anodic bonding and this preferably occurs at approximately room temperature.

18. (Amended) A method according to [any one of claims] claim 10 [to 17], wherein the titanium acts as a getter to reduce the gas pressure in a sealed cavity after anodic bonding and during or after a heat treatment.

19. (Amended) A method according to [any one of] claim 10 [to 18], wherein the first layer is wet etched in an aqueous solution of ammonium hydroxide and hydrogen peroxide.

21. (Amended) A method according to [any one of claims] claim 10 [to 20], wherein the first and second layers are placed on the glass substrate instead of the semiconductor substrate to ensure that there is low stray capacitance within the device.

REMARKS

The above amendments are made to delete multiple dependency claim language. The claims are believed to be in condition for examination, and such action is earnestly requested.

Respectfully submitted,

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IMPROVEMENTS TO MICRO-ELECTROMECHANICAL DEVICES

This invention relates to micro-electromechanical devices and, in particular, to devices, which are fabricated from several substrates and subjected to anodic bonding during their manufacture.

A number of micro-electromechanical devices, such as accelerometers, pressure sensors, angular rate sensors, inclineometers, etc, are known.

It is well known with such micro-electromechanical devices to provide a glass substrate cover over a semiconductor substrate. Such a cover provides mechanical protection to the device, and can provide a vacuum cavity. The glass can also provide a mount for some of the required electrical components. Placing electrical components on the glass substrate rather than the semiconductor substrate reduces the stray capacitance in the micro-electromechanical device. The glass is bonded to the semiconductor substrate by a process known as anodic bonding and this procedure is known to be harsh and potentially damaging to the components involved.

For example, due to the high temperatures involved, some of the materials may deform so causing defects, which adversely affect the performance of the micro-electromechanical device. Further, stress related effects may disrupt proper functioning of the device after the bonding process.

According to a first aspect of the present invention, there is provided a device comprising electrical and mechanical components comprising multiple layers in which:

a first layer or first set of layers is arranged to function as one or more electrodes or conductors; and

a second layer is arranged to function as one or more press contacts or wire bond pads, wherein

the second layer has different physical properties than the first layer or first set of layers, wherein the first layer

or set of layers is relatively hard or tough and the second layer is relatively soft or malleable.

Preferably, the first layer or first set of layers is formed from a titanium or, more preferably, from titanium and titanium nitride.

Preferably, the second layer is formed from one of aluminium or gold. The first and second layers may be formed on alkali containing borosilicate glass.

Preferably, the first layer is approximately 7000 Å thick and the second layer is approximately 5000 Å thick. The formation, and use of the press contacts as conductors, requires that the thickness of the layers is accurate and reproducible.

The present invention provides electrical and mechanical components which meets the diverse requirements of several functions within the micro-electromechanical device and which can withstand the harsh and potentially damaging environment during anodic bonding. In an embodiment of the invention the components mounted on the glass substrate include capacitor electrodes, conductors, press contacts, and wire bond pads. The conductors are both for electrical connection of the capacitor electrodes and the electric shields. The press contacts form electrical connection to conductors on the mating silicon substrate when the glass and silicon substrates are bonded together by the anodic bonding process.

According to a second aspect of the present invention, there is provided a method of forming electrical and mechanical components in a micro-electromechanical device, the method comprising the steps of:

forming a first layer or set of layers which functions as one or more electrodes or conductors; and

forming a second layer which functions as one or more press contacts or wire bond pads, wherein

the second layer has different physical properties than the first layer or first set of layers, wherein the

first layer or set of layers is relatively hard or tough and the second layer is relatively soft or malleable.

Preferably the first and second layers are etched to form the electrodes/conductors or bond pads/press contacts respectively. This process may include photolithography.

Preferably, the hard layer or set of layers is the first layer or set of layers to be deposited on the glass substrate and, subsequently, the second layer is deposited on top of the first layer. The layers may then be subjected to two or more photolithography steps which firstly pattern the wire bond pads and press contacts in to the second layer and, secondly, pattern the conductors and electrodes, as well as, the wire bond pads and press contacts, in to the first layer or set of layers. The pattern for the first layer must include all the features of the second layer because the first layer is under the second layer.

The first layer may be titanium.

The titanium may act as a getter to reduce the gas pressure in a sealed cavity after anodic bonding and this preferably occurs at approximately room temperature.

Preferably, the titanium layer forms electrodes which remain flat during anodic bonding and which do not form permanent bonds to a flexible silicon structure during anodic bonding. This also applies to the titanium when used as one or more electrical conductors.

An embodiment of the present invention will now be described with reference to the accompanying drawings in which:

Fig. 1 is a plan view schematic of a glass substrate with one set of components;

Fig. 2 is a cross-sectional view schematic of the multiple layers after deposition and before patterning;

Figs. 3 and 4 are cross-sectional view schematics through the substrate and layers after the second layer is patterned and after the first set of layers is patterned; and

Fig. 5 is a cross section schematic view of a complete device according to the present invention.

In Fig. 1 four components are depicted; 1 two conductors and an electrode, 2 a wire bond pad and press contacts, all are formed on a glass substrate 3.

Fig. 2 shows a first set of layers 1 to be patterned as a capacitor electrode, conductors and as an underlying layer; a wire bond pad and press contacts. A second layer 2 to be patterned as a wire bond pad and press contacts, and the glass substrate 3.

Fig. 3 shows a first set of layers 1 to be patterned as a capacitor electrode, conductors and as an underlying layer; also a wire bond pad and press contacts, and a second layer 2 that has been patterned as a wire bond pad and press contacts, and the glass substrate 3.

Fig. 4 shows the first set of layers 1 that has been patterned as a capacitor electrode, conductors and as an underlying layer; also a wire bond pad and press contacts, and the second layer 2 that is patterned as a wire bond pad and press contacts, and the glass substrate 3.

Fig. 5 shows a completed device with a first set of layers 1 that is patterned as a capacitor electrode, conductors and as an underlying layer; also a wire bond pad and press contacts, a second layer 2 that is patterned as a wire bond pad and press contacts, the glass substrate 3, and press contacts 4 mounted on silicon substrate 5. Fig. 5 does not show, however the electrical or mechanical components mounted on the silicon substrate, other than the press contacts.

The method of the invention will now be described.

The first 1 and second 2 layers are deposited on the glass substrate 3 in turn by any one of a number of known processes.

The first and second layers are then subjected to photolithography steps which pattern wire bond pads and press contacts firstly in the second layer and then in the first layer together with any conductor and electrodes that

are required. It will be appreciated that the patterns of the first layer must include all of the features of the second layer as it is disposed underneath it.

The photolithography and etching processes, which are proposed to be used with the present invention, are such that the first layer may be wet etched in an aqueous solution of ammonium hydroxide and hydrogen peroxide. Preferably the solution is made up of one part ammonium hydroxide, five parts hydrogen peroxide and nine parts water. The major concern with the etching process is that the etching should be consistent, that any residue is fully removed and that the line definition and line width is controlled.

The first and second layers may be placed on the glass substrate instead of the semiconductor substrate and this ensures that there is low stray capacitance within the device.

The choice of the materials to use for the first and second layers is dependent upon a number of specific characteristics, which the material must exhibit. The first layer or set of layers needs to have the following attributes: conductive, good adhesion to glass, patternable, low stress, good adhesion to glass after anodic bonding, hard, non-stick to flexible silicon structures and low cost. Other materials fulfill these characteristics except they are difficult or impossible to pattern with a wet etchant. Sputter etching cannot be used because it will damage the glass surface before the anodic bonding.

The second layer must be relatively soft or malleable enough to deform under the pressure applied during anodic bonding so that it can form a reliable press contact, which has low-electrical resistance. Further it must function reliably for use as wire bond pad and be patterned using standard photolithography and a wet etchant. Finally, it should also be a low cost material.

The etching of all layers is preferably selective. That is, each layer must be patterned by etching, without effecting the other layer or layers. Further the etching preferably results in excellent line definition and line width control.

During the anodic bonding, flexible silicon structures are pressed against the first layer by extremely high electric fields in the presence of high temperature. The resulting force per unit area between the flexible silicon structure and the first layer or set of layers is extremely high. Accordingly, the material from which the first layer or set of layers is formed should not undergo plastic deformation or permanently change shape under these extreme conditions. While this quality is often referred to as hard, a tough material, which combines high strength and flexibility, will also fulfil this requirement. The material of the first layer must also be inert with respect to silicon under the extreme conditions in which they are processed. As Anodic Bonding is often done in high vacuum. All materials used for substrates and component layers must be vacuum compatible.

CLAIMS

1. A device having electrical and mechanical components the device comprising multiple layers in which:

a first layer or set of layers arranged to function as one or more electrodes or conductors; and

a second layer arranged to function as one or more press contacts or wire bond pads, wherein

the second layer has different physical properties than the first layer, wherein the first layer or set of layers is relatively hard or tough and the second layer is relatively soft or malleable.

2. A device according to claim 1, wherein the first layer or set of layers is formed from titanium.

3. A device according to claim 1, wherein there is a first set of layers formed from titanium and titanium nitride.

4. A device according to any one of the preceding claims, wherein the second softer or more malleable layer is formed from one of aluminium or gold.

5. A device according to any one of the preceding claims, wherein the first layer or set of layers is approximately 7000 Å thick.

6. A device according to any one of the preceding claims, wherein the first layer or set of layers is approximately 3000 Å to 10000 Å thick.

7. A device according to any one of the preceding claims, wherein the second layer is approximately 5000 Å thick.

8. A device according to any one of the preceding claims, wherein the second layer is approximately 2000 Å to 6000 Å thick.

9. A device according to any one of the preceding claims, wherein additional titanium is formed on one or more of the surfaces that form the inner surface of a sealed cavity in the completed device.

10. A method of forming electrical and mechanical components in a micro-electromechanical device, the method comprising the steps of:

forming a first layer which functions as one or more electrodes or conductors; and

forming a second layer which functions as one or more press contacts or wire bond pads, wherein

the second layer has different physical properties than the first layer, wherein the first layer or set of layers is relatively hard or tough and the second layer is relatively soft or malleable.

11. A method according to claim 10, wherein the first layer or set of layers and second layer are selectively etched to form the electrodes/conductors or bond pads/press contact respectively.

12. A method according to claim 10, wherein the patterning processes includes photolithography and etching.

13. A method according to any one of claims 10 to 12, wherein the hard layer is the first layer to be deposited on the glass and, subsequently, the second layer is deposited on top of the first layer.

14. A method according to any one of claims 10 to 13, wherein the layers are then subjected to two or more photolithography steps which firstly pattern the press

contacts and wire bond pads in to the second layer and, secondly, pattern the conductors and electrodes in to the first layer.

15. A method according to any of claims 10 to 14, wherein additional titanium is formed on one or more of the surfaces that form the inner surface of a sealed cavity in the completed device.

16. A method according to any one of claims 10 to 15, wherein the titanium acts as a getter to reduce the gas pressure in a sealed cavity after anodic bonding.

17. A method according to any one of claims 10 to 16, wherein the titanium acts as a getter to reduce the gas pressure in a sealed cavity after anodic bonding and this preferably occurs at approximately room temperature.

18. A method according to any one of claims 10 to 17, wherein the titanium acts as a getter to reduce the gas pressure in a sealed cavity after anodic bonding and during or after a heat treatment.

19. A method according to any one of claim 10 to 18, wherein the first layer is wet etched in an aqueous solution of ammonium hydroxide and hydrogen peroxide.

20. A method according to claim 19, wherein the solution is made up of one part ammonium hydroxide, five parts hydrogen peroxide and nine parts water.

21. A method according to any one of claims 10 to 20, wherein the first and second layers are placed on the glass substrate instead of the semiconductor substrate to ensure that there is low stray capacitance within the device.

ABSTRACT

A device having electrical and mechanical components. The device comprises multiple layers in which:

a first layer or set of layers arranged is to function as one or more electrodes or conductors; and a second layer is arranged to function as one or more press contracts or wire contacts or wire bond pads. The second layer has different physical properties than the first layer, wherein the first layer or set of layers is relatively hard or tough and the second layer is relatively soft or malleable. A corresponding method is provided.

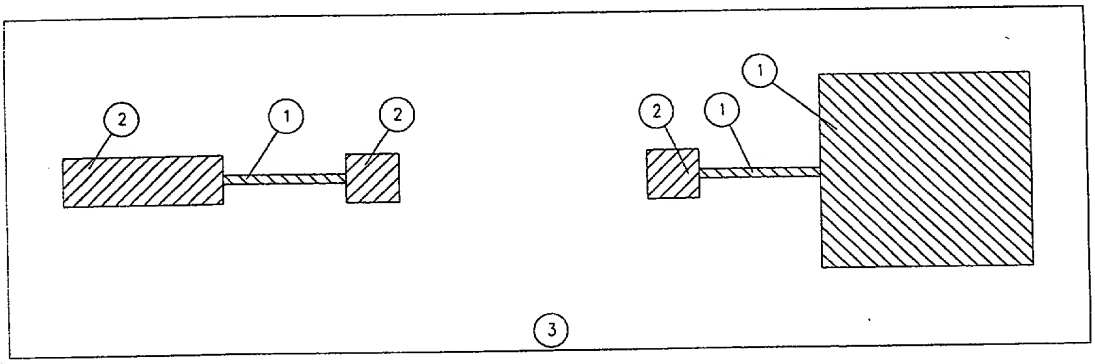

Figure 1

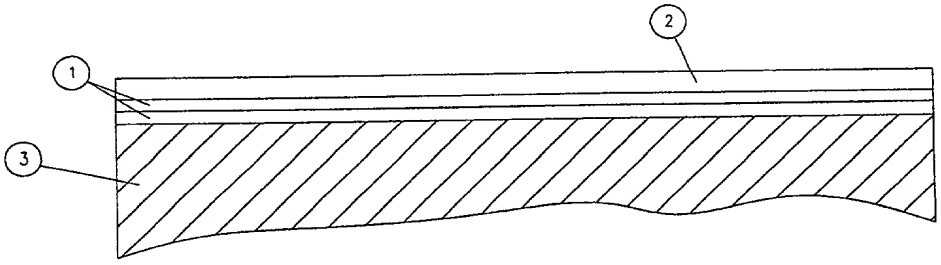

Figure 2

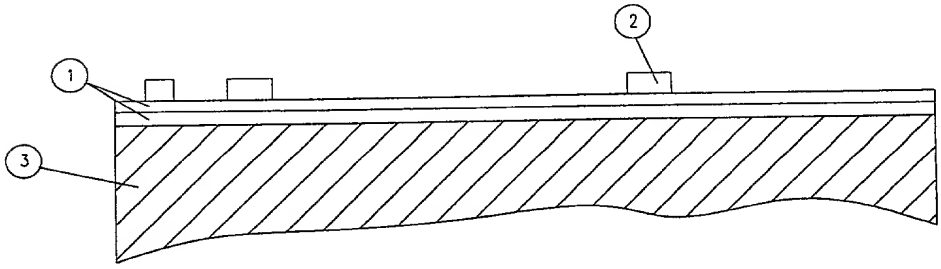

Figure 3

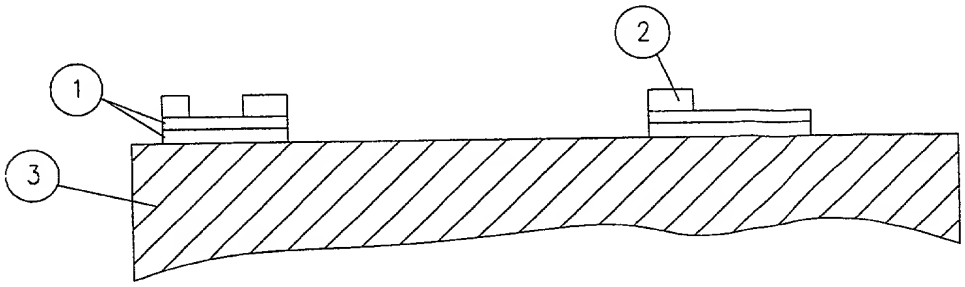

Figure 4

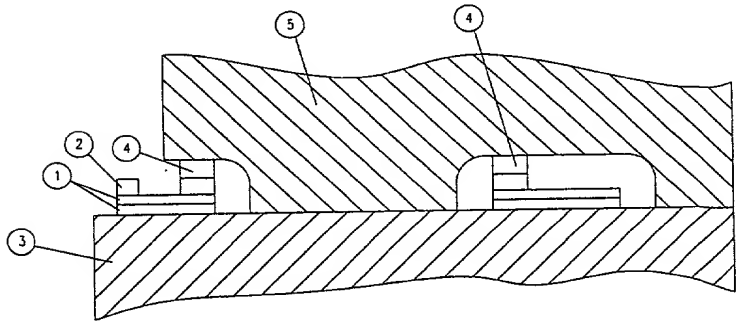

Figure 5

USA

DECLARATION AND POWER OF ATTORNEY

As a below-named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name; I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of subject matter which is claimed and for which a patent is sought on an invention entitled
IMPROVEMENT TO MICRO-ELECTROMECHANICAL DEVICES

the specification of which ☐ is attached hereto or

☐ was filed on Application Number as United States Application Number or PCT International and was amended on (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56. I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for a patent or inventor`s certificate, or PCT international application having a filing date before that of the application on which priority is claimed:

Prior Foreign Application Number(s)	Country	Foreign Filing Date	Priority Not Claimed	Certified Copy Attached? YES	NO
99310582.4	EP	24 DEC 1999	☐	☐	☐
			☐	☐	☐
			☐	☐	☐

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:
Glenn O. Starke 17,031; Eugene R. Sawall 17,431; Daniel D.Fetterley 20,323; George H. Solveson 25,927; Gary A. Essmann 29,376; Thomas M. Wozny 28,922; Michael E. Taken 28,120; Andrew S. McConnell 32,272; Joseph J. Jochman, Jr. 25,058; Peter C. Stomma 36,020; Edward R. Williams, Jr. 36,057; William L. Falk 27,709

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C 1001 and that such willful false statements may jeopardise the validity of the application or any patent issued thereon.

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Country of Citizenship: Norway

Date of signature: 11 October 2000

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Inventor's signature: Svein M Nilsen

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Post Office address: c/o Sensonor asa, PO Box 196, N-3192 Horten, Norway

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Date of signature: 11 October 2000

Full name of Third Inventor: Soheil HABIBI

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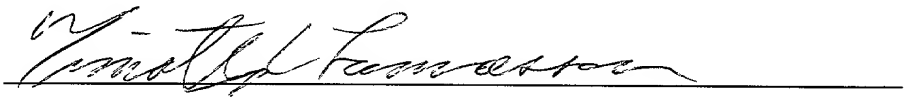
Country of Citizenship: Norway

Date of signature: 11 oct. 2000

Full name of Fourth Inventor: Timothy LOMMASSON

Inventor's signature: 

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